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Effect of reactive gas environment on domain structure and local switching of $LiNbO_3$ thin films deposited on Si(001) by radio-frequency magnetron sputtering

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Lithium niobate $LiNbO_3$ (LN) is of great interest to engineers and scientists due to its excellent opto-acoustic, electro-optical, pyroelectric, and ferroelectric properties [1]. LN thin films are especially attractive for the applications in the integrated optoelectronics. Variety of devices, such as radiofrequency filters and resonators, surface acoustic wave generators, and opto-acoustic devices, are developed with LN-based heterostructures [2, 3].

In this contribution, we present a study of ferroelectric domain structure and electrical properties of the Si(001)-LN heterostructures formed by RF-magnetron sputtering (RFMS) at different sintering conditions. The 300 nm-thick LN films were fabricated by RFMS of the single-crystalline lithium niobate target in the Ar and Ar(60%)+O_2(40%) environments (0.15 Pa). Wafers of single-crystalline silicon of (001) orientation with n-type conductivity and about 4.5 Ω·cm resistivity were used as the substrates. During RFMS process, the substrates located at the distance of 5 cm over the target erosion zone were heated up to 550 °C. The sputtering was performed with 50 W magnetron power.

Films, fabricated in the pure Ar atmosphere (LN-Ar) with secondary $LiNb_3O_8$ phase demonstrate low piezoresponse and high conductivity, which makes local switching impossible. Contrary, using the 60% Ar + 40% O_2 gas environment (LN-Ar/O_2) leads to formation of the single-phase LN films with lower conductivity and high piezoelectric response, comparable with bulk LN. PFM measurements reveal the ferroelectric domain structure, which can be switched by electric field. The roughness of both films is almost the same, despite significant differences in morphology. Thermal annealing in air at 750 °C during 2 h led to significant decreasing of surface roughness in LN-Ar film. Contrary, LN-Ar/O_2 film topography and domain structure almost unchanged after annealing.

The obtained results can be used for development of the devices based on LN-film heterostructures.

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